

1 **ACTIVE-OVER-PASSIVE COORDINATED MOTION WINCH**

2 **FIELD OF THE INVENTION**

3 This invention relates to an active-over-passive
4 coordinated motion winch; particularly to an active-over-
5 passive coordinated motion winch suited for minimizing the
6 relative movement between a payload position and a destination
7 position occurring commonly in offshore operations.

8

9 **BACKGROUND OF THE INVENTION**

10 One of the challenges in working on offshore operations is
11 dealing with the constant motion due to the ocean's waves. The
12 constant heaving and surging of the waves presents numerous
13 challenges to those involved in the transfer of payloads from
14 ships or platforms to positions on or below the ocean's
15 surface.

16 In a typical lowering situation, the payload is first
17 lifted off the deck of a ship using a winch having a cable
18 running through a sheave rotatably mounted on an A-frame or
19 crane boom. The crane or A-frame luffs overboard and the winch
20 cable is paid out to lower the load. Once the payload touches
21 the peaks of the waves, the ocean's influence causes relative
22 motion between the ocean's surface and the object being moved.
23 The relative motion engendered between the ocean's surface and
24 the object being moved must be taken into account and
25 compensated for to accurately deliver the payload. Movement of

1 towed loads that travel close to the ocean floor represent a
2 risky endeavor for many reasons, one of which is that large
3 relative degrees of motion are induced into the towed load due
4 to the ship's response to movement of the water's surface.
5 Docking or maneuvering an object suspended from a ship's crane
6 or other lifting device near fixed objects, in the ocean or on
7 the ocean floor, is nearly impossible unless special means are
8 taken to reduce or eliminate the relative motions.
9 Additionally, when the relative motions are in excess of the
10 load's terminal velocity in the water, snap loads occur in the
11 lowering cable. These snap loads are dangerous to the survival
12 of the cable, its terminations, and to the load and lifting
13 device in general. Since these relative motions increase with
14 increasing seas, the range of weather in which these lowering
15 operations can be carried out is restricted. Since larger
16 ships induce smaller motions, larger ships are often required
17 for critical lowering operations.

18 Various heave compensation devices have been proposed in
19 an effort to overcome these difficulties. These devices
20 generally attempt to maintain the load in a more or less fixed
21 position relative to the earth, regardless of the motions that
22 the ship is undergoing by creating reciprocal movements in the
23 lowering cable in an attempt to compensate for the relative
24 motion. Control of these devices may be either passive or
25 active, with relative expense, space and weight considerations
26 being deciding factors in this regard. Various mechanisms have

1 been utilized in attempting to raise and lower the required
2 amount of cable to produce the reciprocal movements, including
3 active winch drums, flying sheaves, and nodding booms.

4

5 PRIOR ART

6 U.S. Pat. No. 4,593,885 discloses a motion compensating
7 device which is installed on a lift line and situated between
8 a crane and an object to be lifted. The device consists of a
9 hydraulic system and sheave mechanical system arrangement
10 together with a balancing system for a given load range.

11 U.S. Pat. No. 4,354,608 discloses a motion compensating
12 device for a crane hoist. A counterweight, connected to the
13 reeving system, maintains a level of pretension upon the line.
14 A hydraulic cylinder provides a cushioning effect at
15 both ends of the counterweights travel and allows locking
16 movement of the counterweight.

17 U.S. Pat. No. 4,544,137 provides a motion-compensated
18 lifting apparatus which provides a traveling weight for
19 maintenance of tension upon the load-lifting member, and a
20 locking mechanism for prevention of movement of the traveling
21 weight in one direction. Load direction sensing devices
22 prevent lifting when the vessel is falling.

23 U.S. Pat. No. 4,632,622 provides an apparatus for
24 transferring cargo including a pivotally connected linkage for
25 connecting two locations so as to accommodate relative movement
26 therebetween. Interaction of the linkage via the use of

1 hydraulic cylinders articulates a compensating motion between
2 the two locations.

3 U.S. Pat. No. 5,685,683 teaches a system for unloading
4 bulk material from a ship. A float is positioned in the water
5 transverse from and intermediate the ship and a stationary
6 land-fixed location. An outer intake end of a pivotal bulk
7 conveyor on the float is supported and maintained at a fixed
8 height above the body of water and adjacent the ship. An
9 opposite inner outlet end of the pivotal bulk conveyor on the
10 float is supported at a fixed height above the stationary
11 location. As the material is moved, it is transferred to an
12 intermediate bunker car which is moved synchronously
13 longitudinally with the pivotal bulk conveyor and the bucket
14 conveyor.

15 U.S. Pat. No. 5,028,194 is drawn to a marine crane having
16 an additional controllable variable lifting capability which is
17 operably connected with the crane's load line and separately
18 connected to the surface upon or from which an object is being
19 lowered or lifted. The motion of the crane is compensated to
20 provide for safe initial lifting of cargo from a supply vessel
21 in response to wave action.

22 U.S. Pat. No. 5,114,026 describes a hoisting device
23 including a cable controlled conventional crane winch assembly
24 which operates in conjunction with a traction winch assembly
25 inclusive of a traction device and storage winch. The use of
26 the crane winch and traction winch assembly, in concert,

1 enables both critical and long haul travel of cargo.

2 U.S. Pat. No. 5,511,922, teaches a cargo loading and
3 unloading system. A transport car carrying weight enters the
4 ship through a gunwale opening via a ramp. A lift table, which
5 permits the car to board, is positioned by various raising and
6 lowering mechanisms and sensors which operate under the
7 direction of a controller mechanism. Ramp angle and
8 horizontality are maintained within fixed limits irrespective
9 of the relative displacement of the ship's hull with respect
10 to the adjacent wharf, so as to maintain smooth operation of
11 the transport car between the wharf and lift table.

12 Although the specialized loading and unloading equipment
13 listed above does have the ability to partially compensate for
14 the wave motion, they also have a number of disadvantages. One
15 disadvantage is the complexity and mass of many of these
16 systems which limits their usefulness and the environments in
17 which they can be utilized. A disadvantage of completely
18 passive systems is they are only able to compensate for a
19 portion of the relative motion incurred by most payloads. A
20 disadvantage of completely active systems is they require
21 enormous amounts of horsepower once there is a significant
22 overboard load. Additionally, completely active systems
23 attempting to predict a ship's motion have failed to compensate
24 for conditions such as rogue waves. Loss of feedback with
25 either type of these systems results in dangerous conditions
26 for operators as there is no back-up system to compensate for

1 snap loads.

2 Accordingly, what is lacking in the art is an active-over-
3 passive coordinated motion winch. The active-over-passive
4 coordinated motion winch should include a primary passive heave
5 compensation assembly and a secondary active heave compensation
6 assembly. The passive assembly should cooperate with a control
7 assembly to substantially carry the load and passively
8 compensate for a large portion of motion due to the ocean's
9 waves. The active assembly should cooperate with the passive
10 assembly and actively compensate for at least a portion of the
11 remaining wave motion.

12

13 **SUMMARY OF THE INVENTION**

14 The instant invention is directed to an active-over-
15 passive coordinated motion winch designed to be used in
16 combination with a class of existing offshore lifting systems
17 such as A-Frames, booms or cranes. The configuration of this
18 new system allows a remote operated vehicle (ROV) or any other
19 launched load to be firmly captured until it is delivered to
20 the desired destination. The configuration of the system also
21 permits towed loads, such as sonar devices, to closely maintain
22 level tow paths along the sea floor. This greatly enhances
23 data acquired from such towed instrument packages, especially
24 when used for bottom mapping and/or search and discovery
25 missions.

26 The winch assembly includes a drum having a hub defining

1 an axis of rotation and a pair of flanges at opposing ends of
2 the hub and perpendicular to the axis of rotation.
3 Mechanically linked to the drum is a control assembly, a
4 passive heave compensator and an active heave compensator to
5 provide selective rotation to the drum. The passive heave
6 compensator assembly cooperates with the control assembly to
7 substantially carry the weight of the payload and compensate
8 for a substantial amount of the ocean's wave movement. The
9 active heave compensation assembly is constructed and arranged
10 to monitor various parameters within the winch assembly and the
11 passive heave compensation assembly, process the feedback with
12 a computer and apply rotational force or braking force to the
13 winch drum for enhanced stabilization of the payload in all
14 zones of ocean operation.

15 There are five distinct zones of the ocean that each
16 provides problems for ship operations that involve lowering
17 payloads into the water. These same zones affect towed
18 systems equally. They are as follows:

19 Zone I: SPLASH ZONE which is comprised of the distance from
20 the crest of the wave down to the trough of the wave plus two
21 times the height of the package.

22 Zone II: NEAR SURFACE which begins once the package is
23 lowered below the trough of the waves. It's ending is
24 somewhat vague but is typically approximately 200' to 300' in
25 depth.

26 Zone III: WATER COLUMN is basically the water between the

1 ending on Zone II and Zone IV.

2 Zone IV: NEAR BOTTOM is the last 50' of water depth before
3 landing the package on the sea floor.

4 Zone V: the deepest point, the last 15" and landing on the
5 sea floor.

6 Offshore operations vary depending on what the
7 requirements of that particular job are. They can involve
8 operations at any or all of the zones listed above. It is
9 important to remember that the package must pass through
10 these zones on its way to and from the deepest point of the
11 operations. Each zone offers its own set of distinct
12 problems and motion compensation reduces most of the
13 detrimental effects.

14 By utilizing the aforementioned construction, the
15 relative movement between the payload position and the
16 destination position can be substantially neutralized,
17 regardless of whether the payload is neutral (weightless in
18 water), or negative (has weight in water) in all of the
19 aforementioned zones of operation.

20 In addition, because the active heave compensation
21 assembly only needs to supplement the passive portion of the
22 system, horsepower requirements are reduced allowing this
23 portion of the system to be built much smaller and lighter
24 than previous active systems. The aforementioned construction
25 also provides increased safety when compared to prior art
26 active systems. In the event the active heave compensation

1 portion of the instant invention fails, the system reverts to
2 a passive heave compensation system.

3 Accordingly, it is a primary objective of the present
4 invention to teach a coordinated motion compensating winch
5 system for use in a marine environment to instantaneously
6 position a load and thereby neutralize relative movement
7 between a payload position and a destination position.

8 Another objective of the instant invention is to teach a
9 coordinated motion compensating winch system for use in a
10 marine environment which utilizes a primary passive heave
11 compensating assembly to substantially neutralize relative
12 movement between a payload position and destination position.

13 Yet another objective of the instant invention is to
14 teach a coordinated motion compensating winch system for use
15 in a marine environment having a secondary active heave
16 compensating assembly to dynamically enhance the primary
17 passive heave compensating assembly to substantially
18 neutralize relative movement between a payload position and
19 destination position.

20 Other objectives and advantages of this invention will
21 become apparent from the following description taken in
22 conjunction with the accompanying drawings wherein set forth,
23 by way of illustration and example, certain embodiments of
24 this invention.

25 The drawings constitute a part of this specification and
26 include exemplary embodiments of the present invention and

1 illustrate various objectives and features thereof.

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4 **BRIEF DESCRIPTION OF THE DRAWINGS**

5 Figure 1 is a block diagram illustrating the instant
6 invention.

7 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

8 Although the invention will be described in terms of a
9 specific embodiment, it will be readily apparent to those
10 skilled in this art that various modifications,
11 rearrangements and substitutions can be made without
12 departing from the spirit of the invention. The scope of the
13 invention is defined by the
14 claims appended hereto.

15 Referring to Figure 1, a block diagram for an active
16 over passive coordinated motion winch device of the instant
17 invention is illustrated generally at 100. The active over
18 passive coordinated motion winch is particularly suited for
19 use in a marine environment to position a payload and
20 neutralize relative movement between a payload and a
21 destination position. The instant invention winch generally
22 includes a winch assembly 10, a control assembly 20, a
23 passive heave compensation assembly 50 and an active heave
24 compensation assembly 70.

25 The winch assembly 10 includes a drum 12, said drum
26 having a hub 14 defining an axis of rotation A and a pair of

1 flanges 16 at opposing ends of said hub and perpendicular to
2 said axis of rotation. The drum and flanges cooperate to
3 facilitate storage, take up and pay out of one or a group of
4 flexible elongate member(s) (not shown) in continuous evenly
5 distributed coils as is well known in the art. Suitable
6 flexible elongate members may include, but should not be
7 limited to, wire rope cables, ROV umbilical cord,
8 communications cable, combinations thereof and the like.

9 The control assembly 20 is generally constructed and
10 arranged to selectively and operatively engage the winch
11 assembly 10 whereby variable torque and rotational speed or
12 free rotation of said drum 12 is provided. A main hydraulic
13 power unit 22 is fluidly connected via a primary supply tube
14 26 to supply pressurized liquid to a primary hydraulic motor
15 24. The primary hydraulic motor is mechanically connected to
16 the drum 12 by means well known in the art for providing
17 selective power assisted rotational movement thereto. A
18 directional control valve 28 is fluidly connected along the
19 primary supply tube 26 between the main hydraulic power unit
20 22 and the primary hydraulic motor 24. The directional
21 control valve is constructed and arranged for infinitely
22 variable positioning capability. Thus it can control the
23 direction of fluid flow through the main hydraulic motor as
24 well as the amount of fluid allowed to flow through the main
25 hydraulic motor. Operation of the directional control valve
26 28 in a first direction permits the pressurized liquid to

1 flow from the hydraulic power unit 22 to the primary
2 hydraulic motor 24, via the primary supply tube 26, to rotate
3 the primary hydraulic motor 24 in a first direction; and
4 operation of the directional control valve in a second
5 direction causes the primary hydraulic motor to rotate in a
6 second direction. Directional control valves either
7 mechanical, electro-mechanical, pneumatic-mechanical, servo-
8 mechanical or suitable combinations thereof, that are
9 suitable for infinitely controlling hydraulic fluid flow are
10 well known in the art. In the preferred non-limiting
11 embodiment the directional control valve utilized is a
12 manually actuated, spring-centered, three way valve.

13 The passive heave compensation assembly designated
14 generally at 50 includes means for providing passive
15 coordinated reciprocal movement between the payload position
16 and the destination position. The means for providing
17 passive coordinated reciprocal movement between said payload
18 position and said destination position generally includes a
19 gas spring accumulator 52. The gas spring accumulator
20 includes a variable volume gas portion 54 and a variable
21 volume oil portion 56, said gas portion and said oil portion
22 being separated by a piston member 58. The gas portion 54 is
23 fluidly coupled to an infinitely variable gas pressure source
24 via a gas supply tube 60. The gas pressure source
25 illustrated herein as at least one tank 62 filled with
26 compressed fluid. The oil portion 56 is fluidly coupled to

1 said primary supply tube 26 preferably between the primary
2 hydraulic motor 24 and the directional control valve 28. The
3 gas spring accumulator 52 is constructed and arranged to
4 passively dampen response of the winch drum 12 thereby
5 reducing relative movement between the payload position and
6 destination position. The means for providing passive
7 coordinated reciprocal movement between the payload position
8 and the destination position may also include a gas
9 intensifier 64 fluidly connected to the gas supply tube 60
10 preferably between the gas pressure source 62 and the gas
11 portion 54 of the gas spring accumulator 52. The gas
12 intensifier 64 is constructed and arranged to accept
13 pressurized gaseous fluid from the gas pressure source 62 at
14 a first pressure and deliver the gaseous fluid to the gas
15 portion 54 of the gas spring accumulator 52 at a second
16 pressure. In the preferred non-limiting embodiment the
17 second pressure is greater than said first pressure. In a
18 most preferred embodiment the first pressure is at least
19 about 500 pounds per square inch and the second pressure is
20 up to about 5,800 pounds per square inch.

21 The active heave compensation assembly generally
22 designated at 70 includes means for providing active
23 coordinated reciprocal movement between the payload position
24 and the destination position. The means for providing active
25 coordinated reciprocal movement generally includes a
26 secondary hydraulic power unit 72 for supplying pressurized

1 liquid to a secondary hydraulic motor 74, said secondary
2 hydraulic power unit fluidly coupled to said secondary
3 hydraulic motor via a secondary supply tube 76. The
4 secondary hydraulic motor is mechanically connected to said
5 drum 12 for providing selective power assisted rotational
6 movement thereto. A servo-valve 76 is fluidly connected
7 along said secondary supply tube 78 preferably between said
8 secondary hydraulic power unit 72 and said secondary
9 hydraulic motor, the servo-valve having a controller 80 for
10 generating a signal to said servo-valve in response to data
11 received from at least one sensory input 82, wherein
12 pressurized fluid supplied by said secondary hydraulic unit
13 72 is allowed to flow to said secondary hydraulic motor 74
14 for rotation thereof. Suitable controllers and sensory
15 inputs are well known in the art and may include, but should
16 not be limited to controllers and sensors constructed and
17 arranged to monitor drum acceleration, drum position, drum
18 speed, gas spring piston position, payload acceleration,
19 payload deceleration, gas intensifier pressure, stored fluid
20 pressure, directional control valve position, pressurized
21 fluid pressure, suitable combinations thereof and the like.
22 The active heave compensation assembly 70 may also include a
23 booster accumulator 84 connected along the secondary supply
24 tube 78 between the secondary power unit 72 and the servo-
25 valve 76. The booster accumulator is constructed and
26 arranged to maintain a supply of pressurized fluid during

1 operation of the secondary power supply 72. The booster
2 accumulator includes a variable volume gas portion 86 and a
3 variable volume oil portion 88, the gas portion and the oil
4 portion being separated by a piston member 90.

5 It should also be noted that while the preferred non-
6 limiting embodiment disclosed herein fluidly connects the
7 hydraulic components using tubing alternative means suitable
8 for connecting hydraulic accessories which are well known in
9 the art including, but not limited to hoses, pipes,
10 manifolds, castings and suitable combinations thereof are
11 also contemplated and may be utilized to connect the
12 hydraulic components of the instant invention.

13 All patents and publications mentioned in this
14 specification are indicative of the levels of those skilled
15 in the art to which the invention pertains. All patents and
16 publications are herein incorporated by reference to the same
17 extent as if each individual publication was specifically and
18 individually indicated to be incorporated by reference.

19 It is to be understood that while a certain form of the
20 invention is illustrated, it is not to be limited to the
21 specific form or arrangement herein described and shown. It
22 will be apparent to those skilled in the art that various
23 changes may be made without departing from the scope of the
24 invention and the invention is not to be considered limited
25 to what is shown and described in the specification.

26 One skilled in the art will readily appreciate that the

1 present invention is well adapted to carry out the objectives
2 and obtain the ends and advantages mentioned, as well as
3 those inherent therein. The embodiments, methods, procedures
4 and techniques described herein are presently representative
5 of the preferred embodiments, are intended to be exemplary
6 and are not intended as limitations on the scope. Changes
7 therein and other uses will occur to those skilled in the art
8 which are encompassed within the spirit of the invention and
9 are defined by the scope of the appended claims. Although
10 the invention has been described in connection with specific
11 preferred embodiments, it should be understood that the
12 invention as claimed should not be unduly limited to such
13 specific embodiments. Indeed, various modifications of the
14 described modes for carrying out the invention which are
15 obvious to those skilled in the art are intended to be within
16 the scope of the following claims.

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